PROJECT facts

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Gas Exploration, Production, and Storage

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MICROWAVE PROCESSING: POTENTIAL FOR NEW COMPOSITE MATERIALS FOR ENHANCED DRILLING ASSEMBLIES

Transparent Aluminum

A number of years ago a film episode from the "Star Trek" series captured the imagination of many as the crew's chief engineer showed earthlings how to manufacture a product referred to as "transparent aluminum," required to fabricate an unusually large aquarium on their spaceship. While the concept of transparent aluminum might seem alien to most, similar products have been developed at Penn State University's Materials Research Laboratory (MRL) as part of a larger study that uses microwave processing (MWP) to make composite materials. It was discovered that MWP allows the manufacture of a number of composites including aluminum oxide with a magnesium oxide impurity, forming a transparent, synthetic gem-like material, as shown in Figure 1. Other gem materials (e.g. rubies, etc., Figure 2) can also be manufactured rather quickly by MWP. Furthermore, these composite materials are multi-crystalline, not a single crystal, which results in a less brittle, more durable behavior.

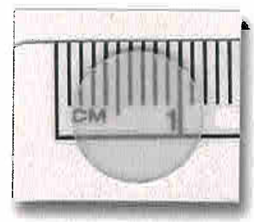

Figure 1: Disc of transparent aluminum showing the ruler beneath.

Figure 2: Transparent aluminum discs with synthetic metallic oxide inserts.

Polycrystalline Diamond

Penn State University's Materials Research Laboratory has also demonstrated another useful application of microwave processing under DOE/FE funded work as part of the National Energy Technology Laboratory's Advanced Drilling Program.

Microwave Processing is ideally suited to make polycrystalline diamond seated in tungsten carbide composite materials. Thermally Stable Polycrystalline Diamond (TSD) products are used extensively in the drilling industry to make drill bits that are more aggressive at cutting rock, resulting in an increased penetration rate. TSD's are also used to protect the drilling assembly from erosion and wear when drilling through abrasive rock.

Typically, TSD's are brazed onto tungsten carbide material, which acts to backup or strengthen the TSD and prevent its brittle nature from degrading the performance of the cutting tool. The diamond must be brazed onto the tungsten carbide because of differences in processing temperatures; conventional processes for manufacturing tungsten carbide would result in the TSD being destroyed by turning the diamond composite material into graphite.

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Microwave Processing: Potential for New Composite Materials for Enhanced Drilling Assemblies

Figure 3 shows TSD material that has been formed within a body of tungsten carbide. This can only be done utilizing microwave processing where the tungsten carbide materials can be formed at the required temperatures in only a fraction of the time used by conventional processes. As a result, the diamond is not turned into graphite and the cutting tool is formed in a single process instead of three separate processes. Penn State University's Partner in commercialization, Dennis Tool Company, is scaling up the process for commercial application and development of a wide range of composite products for the drilling industry.

Figure 3: Thermally Stable Polycrystalline Diamond (TSD) formed within tungsten carbide body.

With such a success rate, we can expect to see new microwave-processed composite materials in many different applications, perhaps even transparent aluminum structures, in the not too distant future.

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NEXT STEP:

Following successful development of microwave processing for diamond composite materials in situ with tungsten carbide (diamond embedded in WC/Co), the feasibility of microwave processing of "functionally graded material" (layered diamond, tungsten carbide, and steel) will be investigated (Figure 4). If successful, an entire drill bit will be manufactured in a single process. This is expected to result in substantial savings in cost and energy.

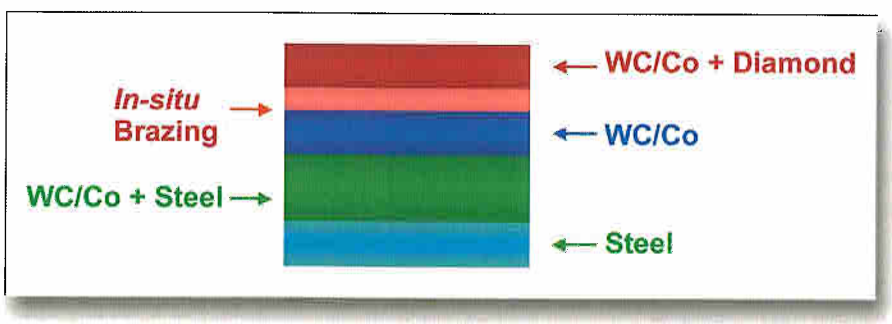

Figure 4: Functionally Graded Composites